# Fire Station Location Study
# For The Tulsa Fire Department

Strategic Management of Change

By: Greg H. Neely
District Fire Chief
Tulsa Fire Department
Tulsa, Oklahoma

An Applied Research Project submitted to the National Fire Academy
as part of the Executive Fire Officer Program

August 1998

## Abstract

The Tulsa Fire Department provides fire protection for 192 square miles with 29 fire stations. There are 43 response units housed at these 29 facilities. The problem: Like most cities Tulsa's core of fire stations was primarily downtown. As the borders of the city expanded, fire stations were built with regard to the direction that the city was growing. This methodology for station location was reasonably adequate given the limited data available for fire station location and justification.

The purpose of this research project was to determine a process that would enable our department to evaluate the effects of relocating, closing and/or adding fire stations across the city. Historical, evaluative, causal-comparative, and action research were conducted to identify the methodology to most effectively determine the most strategic location(s) of current and future fire stations. The following research questions were answered.

1. What emergency risk factors need to be considered for a given response area before determining the need for a fire station?
2. Should any existing fire facilities be combined or closed?
3. Where should future stations be located?

Procedures: A seven-member committee was formed with representatives from the union and management. This committee was formed under the authority of, and answered to the Chief of the Tulsa Fire Department. Committee members utilized a team approach to problem solving. Consensuses were forged and opinions left out unless they were quantified with data.

The research/results supported and successfully provided a means by which to determine the optimum location of both current and future fire stations utilizing weighted risk factors for each given geographic area.

Recommendations included combining and moving a number of fire stations to augment protection efforts in the South and East parts of the city.

# Table of Contents

# Introduction

As with most all fire departments, Tulsa is being held to a greater degree of accountability with its resources. Gone are the days when the chief could simply make a verbal plea for additional money. By decrying the usual "parade of horrors" a passionate chief officer could easily paint a bleak picture to the council of what might occur, should they became less than generous at budget time. While challenging to fire departments, this accountability does provide a tremendous opportunity for fire officials to show how innovative the fire service can be in order to meet or even exceed the expectations of its customers and elected officials.

The problem encountered was one where the city of Tulsa was expanding both to the South and East, taxing what few fire units that were providing coverage to these corridors. Fire officials believed that new stations were needed but had no quantifiable data or methods to determine optimum locations. At the same time existing fire station's potential closure needed to be evaluated to perhaps compensate for the urban flight.

The purpose of this Applied Research Project was to find a method which provided the means or formula for determining and forecasting the ideal location of current and future fire station locations based on community risk factors and customer expectation.

Historical, evaluative and action research were conducted to identify the methodology to most effectively determine the most strategic location(s) of current and future fire stations. The following research questions were answered.

1. What emergency risk factors need to be considered for a given response area before determining the

need for a fire station?

2. Should any existing fire station facilities be combined or closed?

3. Where should future fire stations be located?

## Background and Significance

The Tulsa Fire Department provides fire protection for 192 square miles with 29 fire stations. There are 43 response units housed at these 29 facilities. Like most cities Tulsa's core of fire stations was primarily downtown. As the borders of the city expanded, fire stations were built with regard to the direction that the city was growing. This methodology for station location was reasonably adequate given the limited data available for fire station location and justification.

In 1992 the City of Tulsa hired an outside consulting firm whose report revealed a glut of fire companies in the downtown corridor. Local fire officials knew that there was some obvious disparity in the distribution of resources but it was reasoned that the downtown area (primarily unsprinklered and built in the thirties) needed to have the additional resources due to the potential for disaster. None the less, city administrators decided to assume some of that risk to the downtown area by placing three fire units out of service, resulting in the closure of two fire stations. Fire officials had no data to support the contrary. This same outside consulting firm judiciously recognized the void in protection still remaining in the Southern and Eastern portions of the city (Gay 1992). Over time the need for a Southeasterly fire station waned, and as the recommendation aged, so did its value as current report.

In more recent years budget minded councilors within the City of Tulsa began asking the fire department to provide a report justifying the number of current fire station locations. Having no mechanism in place to provide such a document, a seven-member committee was formed at the request of the Fire Chief to not only address the concerns of the council, but to forecast and project the location of future stations based on community risk and need. This committee was comprised of members from both labor and management working together for the common good.

The closure of two fire stations with the removal of three fire units coupled with the request from the council to justify current facilities, provided the members and the administration of the Tulsa Fire Department the opportunity to utilize the principles and concepts taught in the NFA course "Strategic Management of Change." Particularly applicable to the Tulsa situation are module three Managing Change, module four Leading Change, and module five Personal Aspects of Change. These modules identify the need for business to adapt to a changing environment, becoming proactive and dynamic as an organization, and as individuals, to reflect how we measure up as advocates of change.

The terminal objective of this research project was to determine a process that would enable our department to evaluate the effects of relocating, closing and/or adding fire stations across the city, determine the locations that would best serve the citizens of Tulsa based on community risk, available resources, community expectation, then make recommendations based on the research findings.

# Literature Review

The purpose of the literature review is to reference documents used to assist in the findings of this project. One document utilized by the committee was an independent study from the University of Texas produced by Pieter Sybesma, who at the time was working on his MBA. In his project entitled, “Future Fire Station Locations for the Austin Fire Department and Presentation of a Methodolgy to Determine When to Construct a New Fire Station,” the committee found a wealth of information concerning what community risk factors need to be considered for a given geographic area. Sybesma clearly points out the need to consider multiple risk factors within a community to most accurately assess a true need for a fire station. An example being the need for a prompt response to a recently incorporated area of the city. If the area in question is sparsely populated, has little or no businesses, has not historically had a demand for services provided by the fire jurisdiction, then a prompt response to the area in question would not be as meaningful as it would be to an area that strongly exhibited the aforementioned features (Sybesma 1995).

Additional information gleaned from Sybesma was the use of a lattice type of grid procedure to indicate where stations could be located. The use of circles in a grid became popular in the early 1980's. A grid of diamond shapes is preferred over using circles because it more accurately represented the existing roads system. The use of circles represents an “as the crow flys” approach (Sybesma1995).

Other considerations include what is an adequately prompt response? If a particular department does not provide any level of EMS to the citizens then perhaps one’s priority may be to arrive before flashover occurs. To provide this information the committee sought guidance from the NFPA Handbbook. It has been documented that flashover can quickly occur in a fire that goes beyond the incipient stage. Flashover is dependent on a number of factors including degree of confinement, degree of heat release, available oxygen, type and amount of fuel as well as interior finish. Flashover in an enclosed area is likely to occur when the ceiling temperature reaches approximately 1300 degrees (NFPA1991). Utilizing the standard time temperature curve it can be reasonably deducted that flashover is most likely to occur in an enclosed area within a six to ten minute window. This six to ten minute corridor for flashover to occur, is not the optimum response time if one's department provides any level of EMS service for its citizens. The textbook utilized by the Tulsa Fire Department to train its Emergency Medical Technicians concludes that a response time beyond four minutes greatly diminishes the survivability of a cardiac arrest. The Tulsa Fire Department currently provides First Responder service with defibrillation capabilities. It was a necessary component of this concern to include a four minute response time in accordance with our training standard (Brady 1995). Utilizing the concepts found in the NFA Student Guide Fire Risk Analysis: A Systems Approach, the committee gleaned knowledge needed to assist them in determining risk factors that need to be considered for this study. It was learned that there are a number of questions to be considered to determine risk when applying as systems approach. Who, where and what are in danger? When might an incident occur? Why would incident occur? Why will the fire department have problems? Where will the loss be felt? Once these questions are answered, risk modifiers can be employed to lessen the effects of an incident. Building construction code enforcement, built-in protection systems, training and public education can all mitigate a potential large life and dollar loss at a fire (NFA-SM-FRAS 1984).

The committee realized that the recommendations brought forth would not be taken seriously if it appeared that fiscal responsibility was not considered in its findings. In the book, "Mastering Change Winning Strategies Fore Effective City Planning" (McClendon, Quay, 1988, P.154) the authors discuss the need for governments to seek efficiency. Autonomy, entrepreneurship, and innovation are key elements of governments who are successful at providing efficient services for those it serves. The element of privatization of services that were once thought to be exclusively provided by government are now being entertained and utilized with great success in some circumstances. The committee sought to produce a product that was fiscally feasible without cutting corners to the point that life/ health, property, and the environment were somehow compromised.

Other documents utilized include the BOCA 1993 building code, in order to determine the type of occupancy that were listed as high risk. Utilizing a risk management approach, these types of occupancies needed to be identified and factored in the process of determining if an area needed its own fire facility (BOCA 1993).

Population totals for day and nighttime populations of Tulsa were found in the Indian Nations Council of Government's Foresight 2020: Long Range Transportation Study (INCOG 1995). These data were necessary to determine population shifts/growth in distinct areas both in and out of the city.

# Procedures

A seven-member committee comprised of Tulsa Fire Department personnel from both labor and management was assembled to research a methodology for determining the ideal location for current and future fire stations. Evaluative and historical research was performed to satisfy research question number one: What emergency risk factors need to be considered for a given response area before determining the need for a fire station? Committee members researched and discussed risk factors utilized in similar studies for different municipalities and fire departments. Utilizing the concepts found in the NFA Student Guide Fire Risk Analysis: A Systems Approach, the committee by consensus forged the following factors it found to be most applicable and peculiar for the city of Tulsa: 1. Population totals both day and night, 2. Sensitive sites, 3. Emergency incident totals, 4. First-in response time, 5. Second-in response time.

Population totals for both day and night were gathered from the Indian Nations Council of Government's Foresight 2020: Long Range Transportation Study. In this report 1996 projections for residence (nighttime) and employment populations were calculated. The committee opted to consolidate a variety of special occupancies that present high life risk and peculiar problems for fire departments as opposed to listing and calculating each special occupancy as a risk factor. For the purpose of this study, sensitive sites included all the following: High risk occupancies as defined by the BOCA Code to include, places of worship, schools and day care, board and care facilities, detention centers, institutes providing 24 hour care, hotels motels and boarding houses, multi-family dwellings, high rise occupancies, and tier II reporting facilities. The source of this data was the Tulsa Fire

Department Fire Marshal's Office and the Local Emergency Planning Committee.

To determine first and second in response times, the entire city needed to be divided into distinct zones. Utilizing a computer program called *Flame* which is a fire service planning medium, applicable variables were entered into the program to determine three distinct zones or areas. 1. The zone which could be reach by a fire station before other equipment arrives. 2. The zone which could be reached by a fire station in a specified time (four minutes for the Tulsa study) to determine the first-in response area; this netted the first in area. 3. The zones to which a second arriving apparatus can reach within a specified time; this would net the second-in response time.

The Flame program was then used in conjunction with another program called MapInfo. MapInfo has spreadsheet capabilities and the ability to plot the information on a map. Each of the five risk factors was entered utilizing the two programs. Each risk factor will have a higher value than the rest in a given zone. The highest value for each response zone is used as a benchmark to calculate a ratio for each risk factor.

Example: Fire station A has the greatest number of sensitive sites in its response zone, 150 total. Fire station B has 25 sensitive sites in its response zone. Station B's ratio is calculated by dividing 25 by 150; equaling 0.17. Station A's ratio is calculated by dividing 150 by 150; equaling 1.0. This process is calculated for each risk factor. The totals are then multiplied by 2 in order to give a range from 0.0 to 10.00. A 10.00 would indicate the greatest need or risk for that particular station's response zone. This process is repeated for each risk factor (See Appendix A) Action research was conducted to answer research questions two and three. Utilizing the Flame program containing a model of the city of Tulsa expressways and street system, the program can drive the streets of Tulsa. When applicable variables are set into a given scenario, the program can project which station can reach a given point first. Stations can be added or subtracted and the program will evaluate the scenario and one can view the effects of the changes. Utilizing a three square mile lattice framework containing a series of diamonds, while placing a fire station in the middle of each diamond, provided the optimum location for a fire station to have a four minute response within its diamond. This process was substantiated by 1995 run data which depicted the correlation of the 3 mile diamond to a 4 minute response time. (See Appendix B).

In theory, and without lurking variables, one could select the optimum sights of all fire stations by placing the station in the center of each three-mile diamond. When applying the *Flame* program and comparing its results with 1995 run data, it became readily apparent that some areas of the city of Tulsa were getting a four minute response from the fire department while others were not. Some areas could get several fire units within four minutes while other areas could take over ten minutes to before units arrived. It would not be practical to build a station in each and every diamond without first examining the risk factors for that particular diamond. There may be little or no housing (nighttime population), industry/employment (daytime population), or sensitive sights. These factors all must be considered before a new station is built.

The committee agreed a two-prong approach needed to be utilized before determining the fate of existing and future fire facilities. 1. Fire stations needed to be arranged such that a four minute response time was achieved (closely resemble the diamond grid pattern) 2. Evaluate the risk factors to assure that protection is adequate. The location of future fire stations would be determined adhering to the diamond grid concept however, they would not be built until such time that the risk factors for the area were evaluated and the situation warranted it, based upon priority when calculating the ratios of the identified risk factors. There was now a model in place for determining the optimum location of present and future fire stations for the City of Tulsa.

**Limitations:** The selection and weight of the risk factors, while not arbitrary was somewhat subjective in this process. It was determined by the committee that an exhaustive list of risk factors could be utilized (focus group sessions produced 15 different risk factors) and each factor could be weighted differently depending on the perspective and experience of the committee member. An example would be the Fire Marshal may place more emphasis on sensitive sites, while the Operations Chief sees more emphasis on response times. The committee could not agree on which of the factors held the greatest priority and therefore which would be weighted heavier than less significant factors. For the purposes of simplicity and unheeding debate, the committee of experienced fire executives hammered out the five risk factor theory with each factor carrying the identical weight of the next. In reality, the 15 risk factors identified in the focus group can actually be categorized within the five risk factors: 1. Population 2.Sensitive Sites 3. Emergency Incidents 4. First-In Response Area 5. Second-In Response Area.

Other limitations included the calculations of lurking variables such staffing and equipment for these stations. Some stations may need nothing more than a small apparatus with four firefighters to take care of the predominant risk of that area. Other areas may need a station with multiple companies with pumping and aerial capabilities requiring more personnel such as in a high rise district. It is one thing to determine the need for a station for a particular corridor of the city. It is another thing entirely to anticipate the quantity of personnel and equipment to be housed at these stations. It was agreed by the committee that equipment and staffing needs was beyond the scope of this committee and that more research needed to be completed to determine the level of personnel and equipment needed at the proposed station locations.

## Results

Research question number one: What risk factors need to be considered when determining current and future fire station location? The committee determined that an exhaustive list could be established as risk factors and this list could have individual ratios calculated. The committee reduced previous risk factor list from fifteen to a more concise list of five (5). In order to help simplify an already complex task, the committee determined to consolidate all occupancies and locations presenting special life-safety risks, into a general all encompassing category identified as sensitive sites. It was also determined that population totals for both day and nighttime needed to be considered as a primary risk factor. Other risk factors rounding out the committees list of five include first-in and second-in response times as well as the number of incidents currently occurring in the area in question. It was agreed that each of these risk factors would receive equal weights in the evaluation process. No data available were conclusive that one factor could be more important than another. The completed risk factor list included: 1. Population 2. Sensitive Sites 3. Emergency Incidents 4. First-In Response Area 5. Second-In Response Area.

Questions two: Should any existing fire stations be closed or combined? Utilizing the two prong approach relying on the 3 mile grid diamonds depicting a four minute response time, coupled with the calculation of the risk factors for each zone, the committee concluded four changes needed to occur. 1. Build a new fire station in Southeast Tulsa. 2. Move station 7 to the Southeast approximately 1 mile. 3. Relocate station 22 to the South approximately 1 mile. Close station 11 and divide and utilize its equipment and personnel at the proposed new Southeast fire station and at the proposed relocation of station 22 (see appendix C).

Question number three: Where will future fire stations be built? The committee requested the adoption of a long range plan utilizing the diamond grid pattern as a model for future station locations. Future station should be prioritized based upon the same two prong approach; 1. An imminent need based upon risk factor calculations. 2. Geographically centered as close as practical to the center of the response diamond (see appendix D). Recommendations also included the request for a further study into the effects of closing fire stations 1 and 12. There were a number of lurking variables such as staffing for the predominant risk of unsprinklered high rise for station 1, and city charter considerations in providing mutual aid to a neighboring community with station 12.

# Discussion

The relationship between the applied research results with the findings of other reports and similar process was one that provided a consistent trend or pattern. It has been said that if one wants to test the consistency of a theory, then given applicable parameters the results will be reproducible. Risk management is not a new concept but the comfort level that one has with the risk that is assumed, can be greatly increased through a methodical analytical process that produces consistent results. My interpretation of the results is not one of great revelation. As the committee worked through the process, the findings revealed things that we already knew, felt or assumed. The process however was invaluable and necessary in terms of quantifying our “gut feeling,” a process which does not set well with tight-fisted city administrators. The implications of this project as it relates to the Tulsa Fire Department are good. This research will have (and already has had) a positive impact, in terms of fire station justification, and credibility with city officials and neighborhood associations. This risk management and quantifying process has spawned other similar committees in the area of apparatus placement and staffing levels.

## Recommendations

The problem encountered was one where the city of Tulsa was expanding both to the South and East, taxing what few fire units that were providing coverage to these corridors. Fire officials believed that new stations were needed but had no quantifiable data or methods to determine optimum locations. At the same time, existing fire station's potential closure needed to be evaluated to perhaps compensate for the urban flight.

The goal of this Applied Research Project is to find a method which provided the means or formula for determining and forecasting the ideal location of current and future fire station locations based on community risk factors and customer expectation.

Applying the weighted factor theory coupled with the three-mile diamond grid tool, the committee was able to evaluate the effects of adding, subtracting, and /or combining fire station locations. The results of the research support the committee's recommendation which includes:

1. Build a new fire station in Southeast Tulsa at 5600 South Mingo Road.
2. Move Fire Station 7 from 601 South Lewis, further South and East to 1500 South Columbia.
3. Move Fire Station 22 from 616 South 73rd East Avenue, further South to 1500 South 72nd East Avenue.
4. Close Fire Station 11 at 5009 East 15th Street. Utilize Engine 11 and its personnel to staff the new Southeast Fire Station. Utilize Ladder 11 and its personnel, along with the District Chief, at the new station 22 location.
5. Adopt the three-mile diamond grid for determining the location of future fire stations, prioritizing the

construction utilizing the weighted risk factor concept.

# Reference List

Bergeron, D., Grant, H., Limmer D., Murray R., O'Keefe, M. (7th edition). (1995). Brady EMT Manual. Upper Saddle River, NJ: Prentice Hall

Building Officials & Code Administrators International, Inc. (1993). The BOCA National Building Code/1993 (twelfth edition). Country Club Hills, IL: Author

Gay, William. (1992). Comprehensive resource utilization study of the Tulsa Fire Department Herndon, VA: University City Science Center.

Indian Nation Council of Government (1995). 2020 Foresight: Long Range Transportation Plan Tulsa, OK: Author

McClendon B.W., & Quay R. (1988). Mastering Change-Winning Strategies For Effective City Planning. Chicago, IL: Planners Press

National Fire Academy Student Manual. (1984). Fire Risk Analysis: A Systems Approach, July 1984 (NFA-SM-FRAS). Emmitsburg, MD: Author.

National Fire Protection Association Handbook (17th edition). 1991. Quincy, MA: Author

Sybesma, Pieter (1995, October). An equation for station location. Fire Chief, 55-65.

**APPENDIX A:** Factor totals and ratios for existing fire station arrangement.

| STATION | AREA ($mi^2$) | First in[1] ($mi^2$) | First in/ Area | First in Ratio | Emergency[2] Incidents | Emerg Ratio | Sensit. Sites[3] | Sensit sites Ratio |
|---|---|---|---|---|---|---|---|---|
| 3 | 1.89 | 0.00 | 0.00 | 0.00 | 373 | 0.38 | 32 | 0.25 |
| 26 | 2.61 | 0.14 | 0.05 | 0.08 | 189 | 0.19 | 18 | 0.14 |
| 6 | 9.35 | 0.77 | 0.08 | 0.12 | 99 | 0.10 | 10 | 0.08 |
| 12 | 2.08 | 0.18 | 0.09 | 0.14 | 127 | 0.13 | 20 | 0.15 |
| 4 | 1.36 | 0.00 | 0.00 | 0.00 | 298 | 0.30 | 35 | 0.27 |
| 1 | 1.04 | 0.00 | 0.00 | 0.00 | 275 | 0.28 | 63 | 0.48 |
| 2 | 2.79 | 0.20 | 0.07 | 0.11 | 450 | 0.46 | 30 | 0.23 |
| 11 | 3.53 | 0.13 | 0.04 | 0.06 | 383 | 0.39 | 20 | 0.15 |
| 14 | 4.23 | 0.22 | 0.05 | 0.08 | 241 | 0.24 | 21 | 0.16 |
| 5 | 2.22 | 0.04 | 0.02 | 0.03 | 268 | 0.27 | 57 | 0.44 |
| 15 | 3.83 | 0.41 | 0.11 | 0.17 | 460 | 0.47 | 35 | 0.27 |
| 19 | 2.93 | 0.72 | 0.25 | 0.38 | 403 | 0.41 | 18 | 0.14 |
| 10 | 3.99 | 1.85 | 0.46 | 0.70 | 397 | 0.40 | 22 | 0.17 |
| 16 | 3.78 | 1.10 | 0.29 | 0.44 | 555 | 0.56 | 33 | 0.25 |
| 7 | 2.67 | 0.23 | 0.09 | 0.14 | 580 | 0.59 | 99 | 0.76 |
| 21 | 4.25 | 1.10 | 0.26 | 0.39 | 466 | 0.47 | 44 | 0.34 |
| 31 | 18.30 | 8.31 | 0.45 | 0.68 | 167 | 0.17 | 26 | 0.20 |
| 13 | 8.42 | 5.46 | 0.65 | 0.98 | 290 | 0.29 | 15 | 0.12 |
| 18 | 3.48 | 0.36 | 0.10 | 0.15 | 589 | 0.60 | 91 | 0.70 |
| 22 | 5.13 | 1.74 | 0.34 | 0.52 | 509 | 0.52 | 58 | 0.45 |
| 17 | 7.52 | 4.27 | 0.57 | 0.86 | 533 | 0.54 | 39 | 0.30 |
| 24 | 10.72 | 4.93 | 0.46 | 0.70 | 611 | 0.62 | 48 | 0.37 |
| 23 | 5.50 | 1.12 | 0.20 | 0.30 | 606 | 0.61 | 74 | 0.57 |
| 32 | 16.56 | 10.52 | 0.64 | 0.97 | 309 | 0.31 | 31 | 0.24 |
| 30 | 18.25 | 11.40 | 0.62 | 0.94 | 380 | 0.38 | 49 | 0.38 |
| 25 | 5.62 | 2.07 | 0.37 | 0.56 | 478 | 0.48 | 80 | 0.62 |
| 29 | 7.00 | 2.86 | 0.41 | 0.62 | 505 | 0.51 | 85 | 0.65 |
| 28 | 9.10 | 4.49 | 0.49 | 0.74 | 665 | 0.67 | 85 | 0.65 |
| 27 | 16.37 | 10.88 | 0.66 | 1.00 | 988 | 1.00 | 130 | 1.00 |

## APPENDIX A

*Continued next page.*

| Station | Second in[4] ($mi^2$) | Second in Ratio | Nighttime Population[5] | Daytime Population[5] | Total Population | Population Ratio | TOTAL OF RATIOS (x2) |
|---|---|---|---|---|---|---|---|
| 3 | 0.00 | 0.00 | 5685 | 3296 | 8981 | 0.15 | 1.56 |
| 26 | 0.77 | 0.30 | 3759 | 2104 | 5863 | 0.10 | 1.62 |
| 6 | 3.67 | 0.39 | 6561 | 1744 | 8305 | 0.14 | 1.66 |
| 12 | 0.80 | 0.38 | 2056 | 1438 | 3494 | 0.06 | 1.72 |
| 4 | 0.24 | 0.18 | 2901 | 11840 | 14741 | 0.25 | 2.00 |
| | 0.00 | 0.00 | 2334 | 19038 | 21372 | 0.36 | 2.24 |
| 2 | 1.14 | 0.41 | 5459 | 8931 | 14390 | 0.24 | 2.90 |
| 11 | 1.86 | 0.53 | 11373 | 7790 | 19163 | 0.32 | 2.90 |
| 14 | 2.98 | 0.70 | 12654 | 5217 | 17871 | 0.30 | 2.96 |
| 5 | 1.27 | 0.57 | 8146 | 6555 | 14701 | 0.25 | 3.12 |
| 15 | 2.26 | 0.59 | 13950 | 4326 | 18276 | 0.31 | 3.62 |
| 19 | 2.73 | 0.93 | 4786 | 689 | 5475 | 0.09 | 3.90 |
| 10 | 2.97 | 0.74 | 8155 | 1774 | 9929 | 0.17 | 4.36 |
| 16 | 2.90 | 0.77 | 10817 | 2684 | 13501 | 0.23 | 4.50 |
| 7 | 1.31 | 0.49 | 12118 | 10698 | 22816 | 0.38 | 4.72 |
| 21 | 3.28 | 0.77 | 15578 | 10463 | 26041 | 0.44 | 4.82 |
| 31 | 18.24 | 1.00 | 6468 | 15848 | 22316 | 0.38 | 4.86 |
| 13 | 7.99 | 0.95 | 6611 | 591 | 7202 | 0.12 | 4.92 |
| 18 | 2.71 | 0.78 | 17021 | 5676 | 22697 | 0.38 | 5.22 |
| 22 | 4.33 | 0.84 | 14528 | 7039 | 21567 | 0.36 | 5.38 |
| 17 | 6.75 | 0.90 | 7656 | 10455 | 18111 | 0.30 | 5.80 |
| 24 | 10.5 | 0.98 | 11515 | 3103 | 14618 | 0.25 | 5.84 |
| 23 | 4.73 | 0.86 | 17817 | 18408 | 36225 | 0.61 | 5.90 |
| 32 | 16.42 | 0.99 | 27182 | 4613 | 31795 | 0.54 | 6.10 |
| 30 | 18.25 | 1.00 | 20267 | 7097 | 27364 | 0.46 | 6.32 |
| 25 | 5.15 | 0.92 | 16407 | 22769 | 39176 | 0.66 | 6.48 |
| 29 | 6.96 | 0.99 | 25103 | 11256 | 36359 | 0.61 | 6.76 |
| 28 | 9.10 | 1.00 | 27752 | 21784 | 49536 | 0.83 | 7.78 |
| 27 | 16.37 | 1.00 | 38678 | 20725 | 59403 | 1.00 | 10.00 |
| | | | **363,337** | **247,951** | | | |

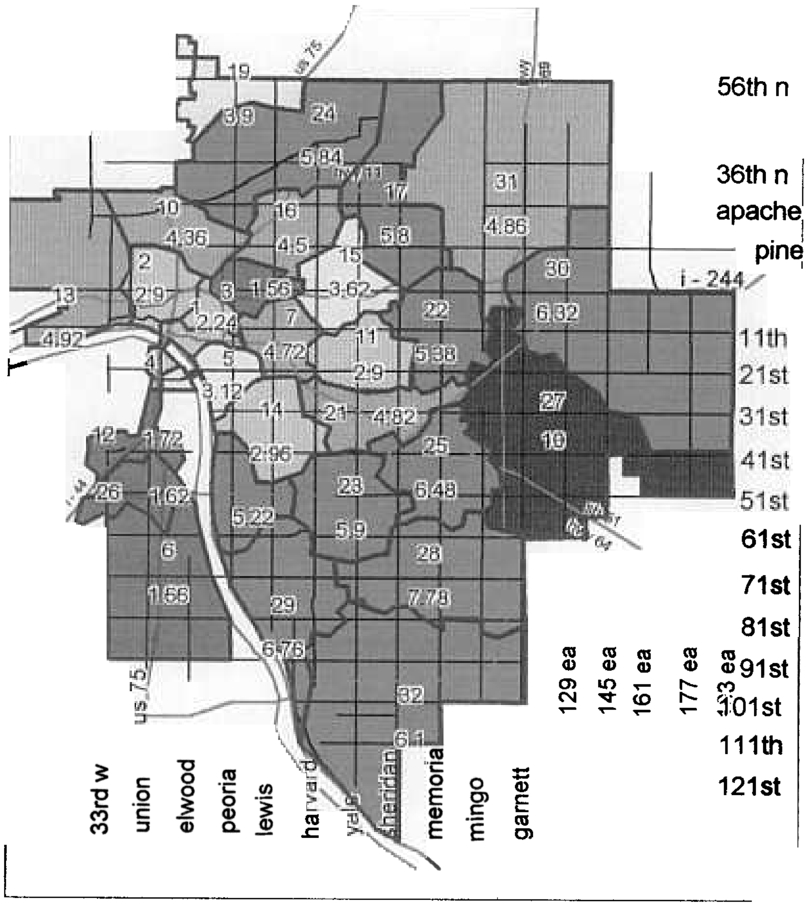



**Figure 1 - Station response areas of existing stations with** fire risk totals.

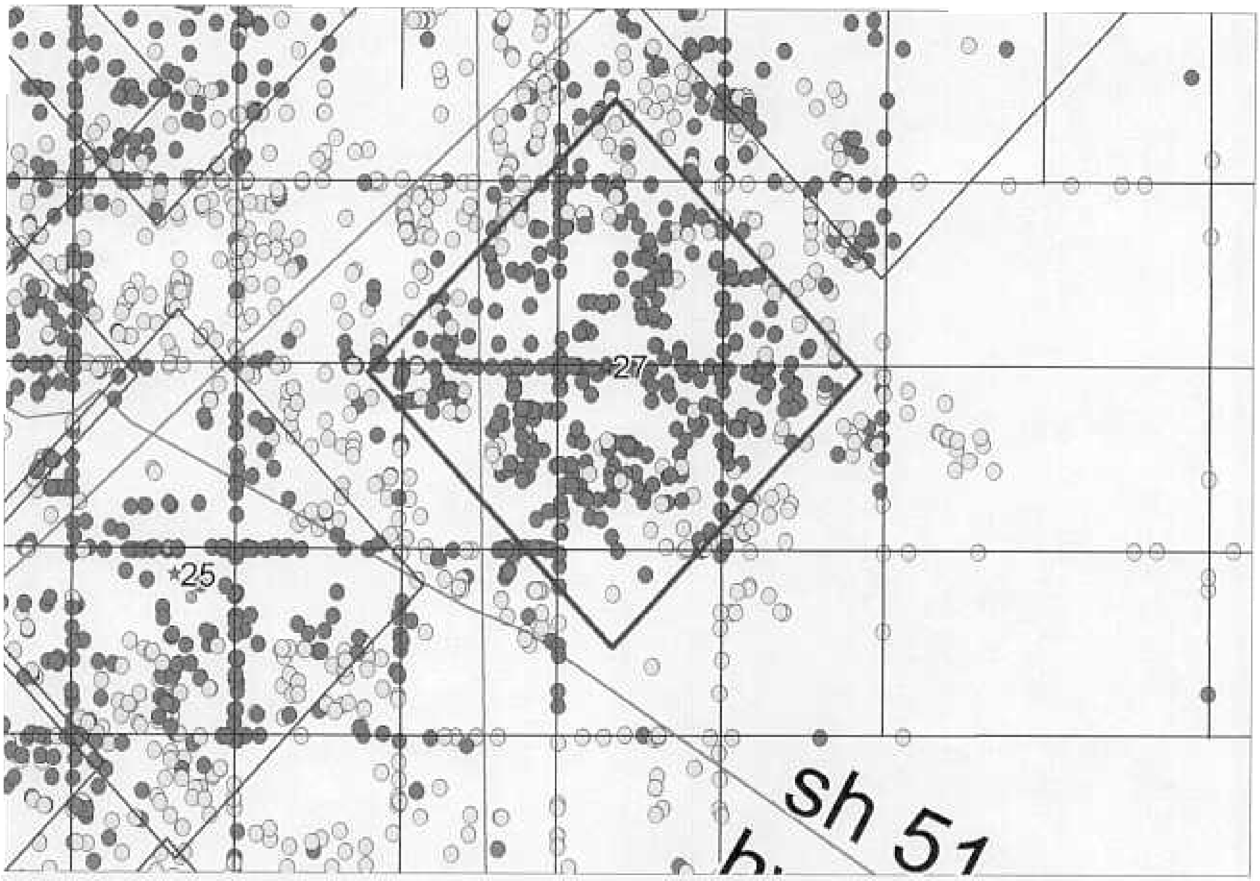
**Table 1** - Summary of Existing and Recommended Fire Station Emergency Risk Totals.
(10 = Maximum)

| STATION (Existing) | TOTAL | TOTAL (All rec.'s complete) |
|---|---|---|
| 3 | 1.56 | 3.58 |
| 26 | 1.62 | 1.92 |
| 6 | 1.66 | 1.99 |
| 12 | 1.72 | 1.98 |
| 4 | 2.00 | 2.42 |
| 1 | 2.24 | 3.04 |
| 2 | 2.90 | 3.56 |
| 11 | 2.90 | - |
| 14 | 2.96 | 3.34 |
| 5 | 3.12 | 3.48 |
| 15 | 3.62 | 5.26 |
| 19 | 3.90 | 4.32 |
| 10 | 4.36 | 4.88 |
| 16 | 4.50 | 5.28 |
| 7 | 4.72 | 5.88 |
| 21 | 4.82 | 4.86 |
| 31 | 4.86 | 5.66 |
| 13 | 4.92 | 5.30 |
| 18 | 5.22 | 6.42 |
| 22 | 5.38 | 8.02 |
| 17 | 5.80 | 7.28 |
| 24 | 5.84 | 6.70 |
| 23 | 5.90 | 7.30 |
| 32 | 6.10 | 6.70 |
| 30 | 6.32 | 7.72 |
| 25 | 6.48 | 6.34 |
| 29 | 6.76 | 8.06 |
| 28 | 7.78 | 7.28 |
| 27 | 10.00 | 9.70 |
| 56th Mingo | - | 6.82 |

Note the higher the number, the greater the need for a new fire station. A low number however does not always indicate the need to close or combine facilities. The predominant risk i.e., High Rise district would require much greater staffing than other areas.

## APPENDIX B

A clear boundary is formed between response times greater than 4 minutes and those less than 4 minutes. The diamond-shaped area corresponding with this boundary is 3 miles tall and 3 miles wide.




1995 run data showing the correlation of the 3-mile wide diamond to 4 minute response times. Green points represent response times under 4 minutes and yellow and red points are over 4 minute responses.

## APPENDIX C - Build new Fire Station at 5600 S. Mingo

The Committee recommends building a new fire station at 5600 S. Mingo. Using the three-mile diamond as a guide, the 56th & Mingo location offers the best coverage considering the current location of surrounding fire stations. The following figures illustrate this fact.

**Figure C1** - The blue diamonds model 4 minute response time from the station at the center of diamond. The red area illustrates the portions of the city not falling within any fire station's response diamond for existing station locations.

**Figure C2** - Building the station at 56th & Mingo aligns its 4 minute response area with station 25 and 28's. Following the 4 minute response time standard, this is the optimum location for the new southeast station.

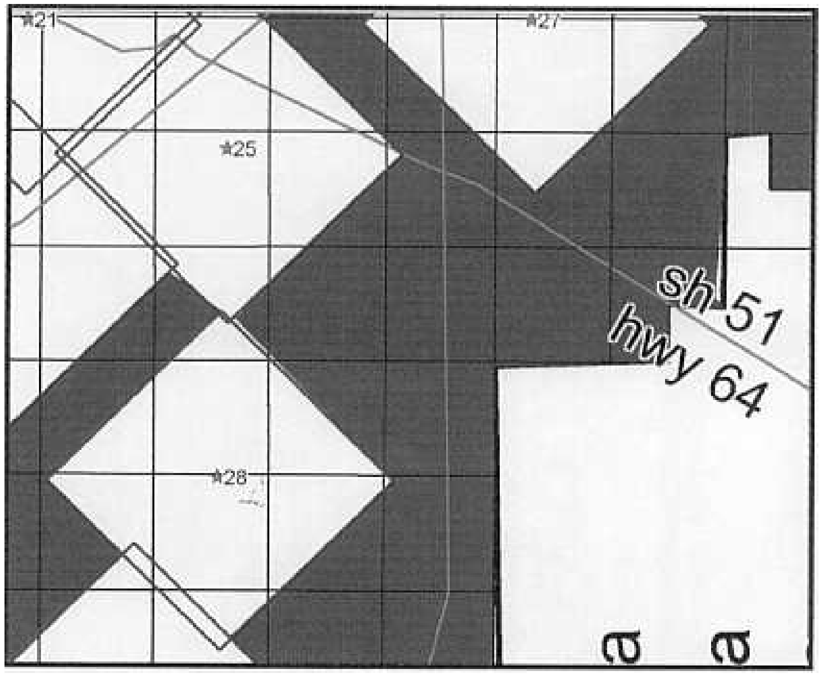


**Figure C1**

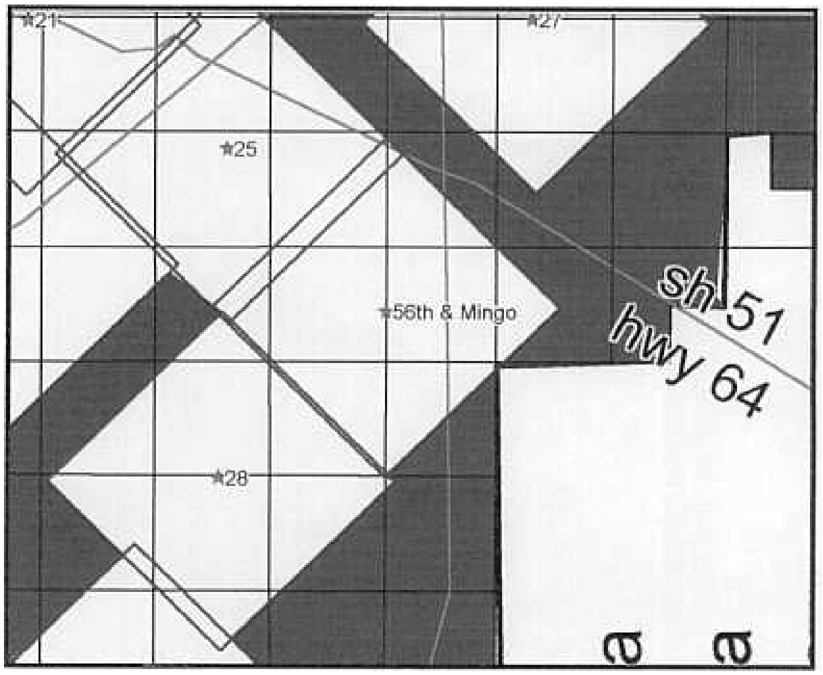


**Figure C2**

## APPENDIX C - Move Fire Station 22 TO 7200 E. 15th

The Committee recommends moving Fire Station 22 to 7200 E. 15th. Using the three-mile diamond as a guide, the 7200 E. 15th location offers the best coverage considering the current location of surrounding fire stations. The following figures illustrate this fact.

**Figure C3** - The blue diamonds model a 4 minute response time from the station at the center of diamond. The red area illustrates the portions of the city not falling within any fire station's response diamond for existing station locations.

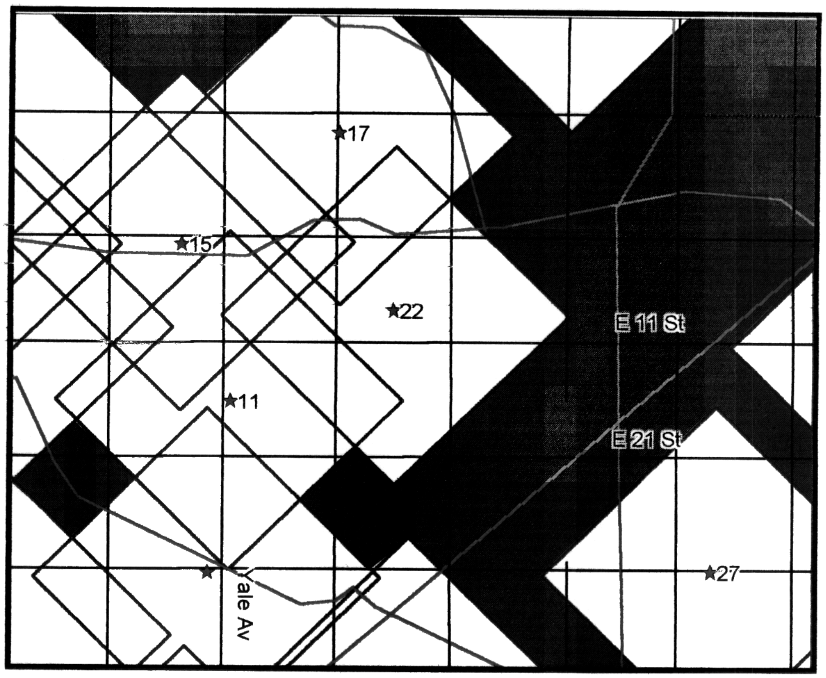



**Figure C3**

The map shows how Station 22's response diamond significantly overlaps Station 11, 15 and 17's areas.

**Figure C4** - Moving Station 22 to 7200 E. 15th aligns its 4 minute response area with Station 15's, 21's and a new Station 7 at 15th & Columbia. Station 11's response area is completely covered by the four surrounding stations, allowing it to be closed.

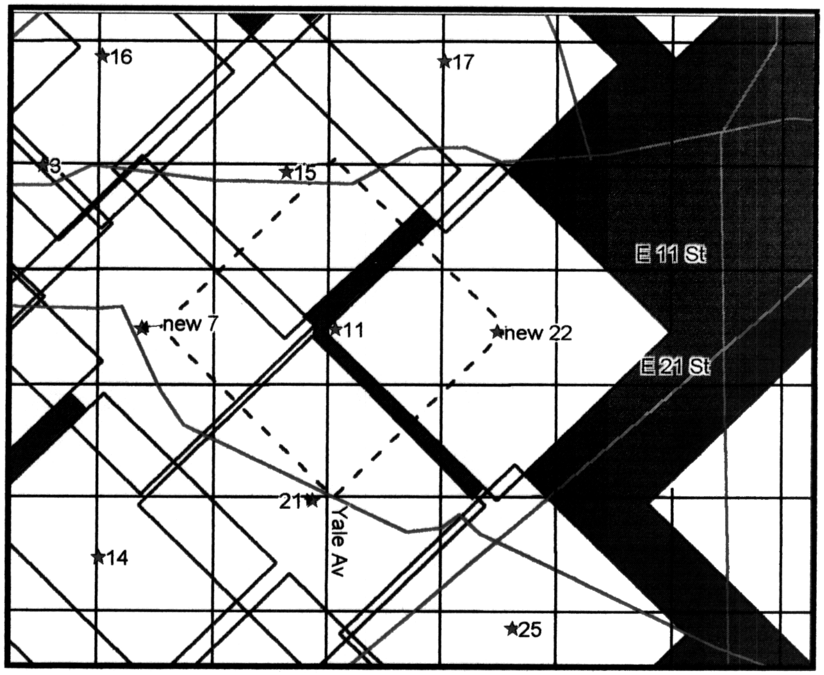



**Figure C4**

**APPENDIX C - Move Fire Station 7 to 1500 S. Columbia.**

The Committee is recommending a new station 7 be built on 15th street in close proximity to Columbia avenue. Using the three-mile diamond as a guide, the 15th & Columbia location is clearly the ideal location for a new station 7, as shown in the following figures.

**Figure C5** -The blue diamonds model a 4 minute response time from the station at the center of the diamond. The red area illustrates the portions of the city not falling within any fire station's response diamond if station 7 is closed.

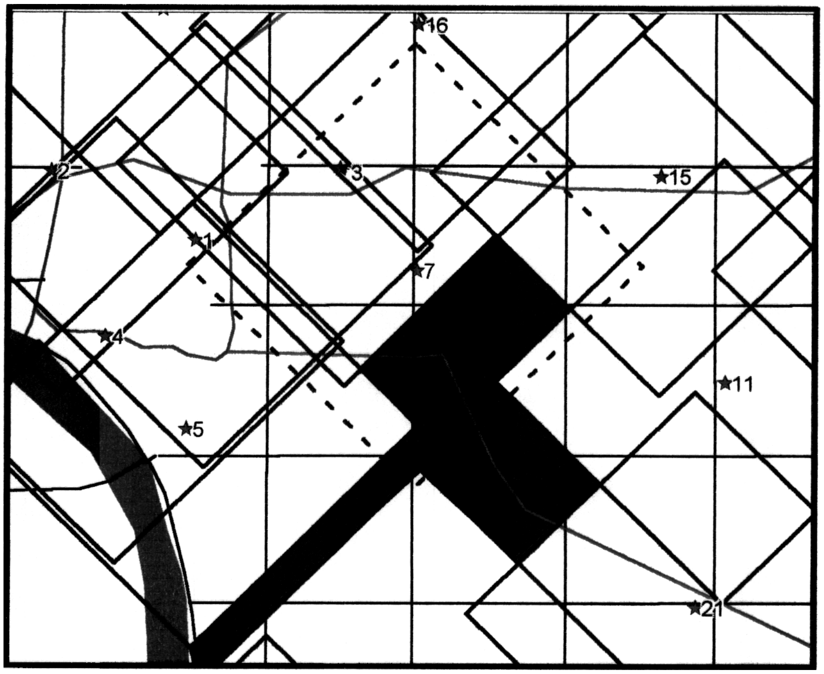



**Figure C5**

**Figure C6** - The red area is most completely covered by placing station 7 near 15th & Columbia.

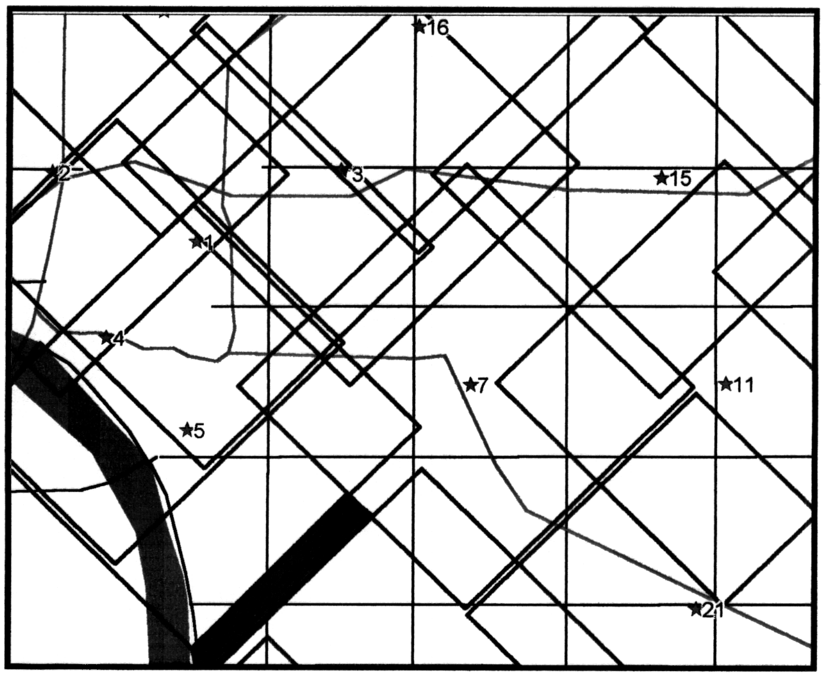



**Figure C6**

**APPENDIX D**

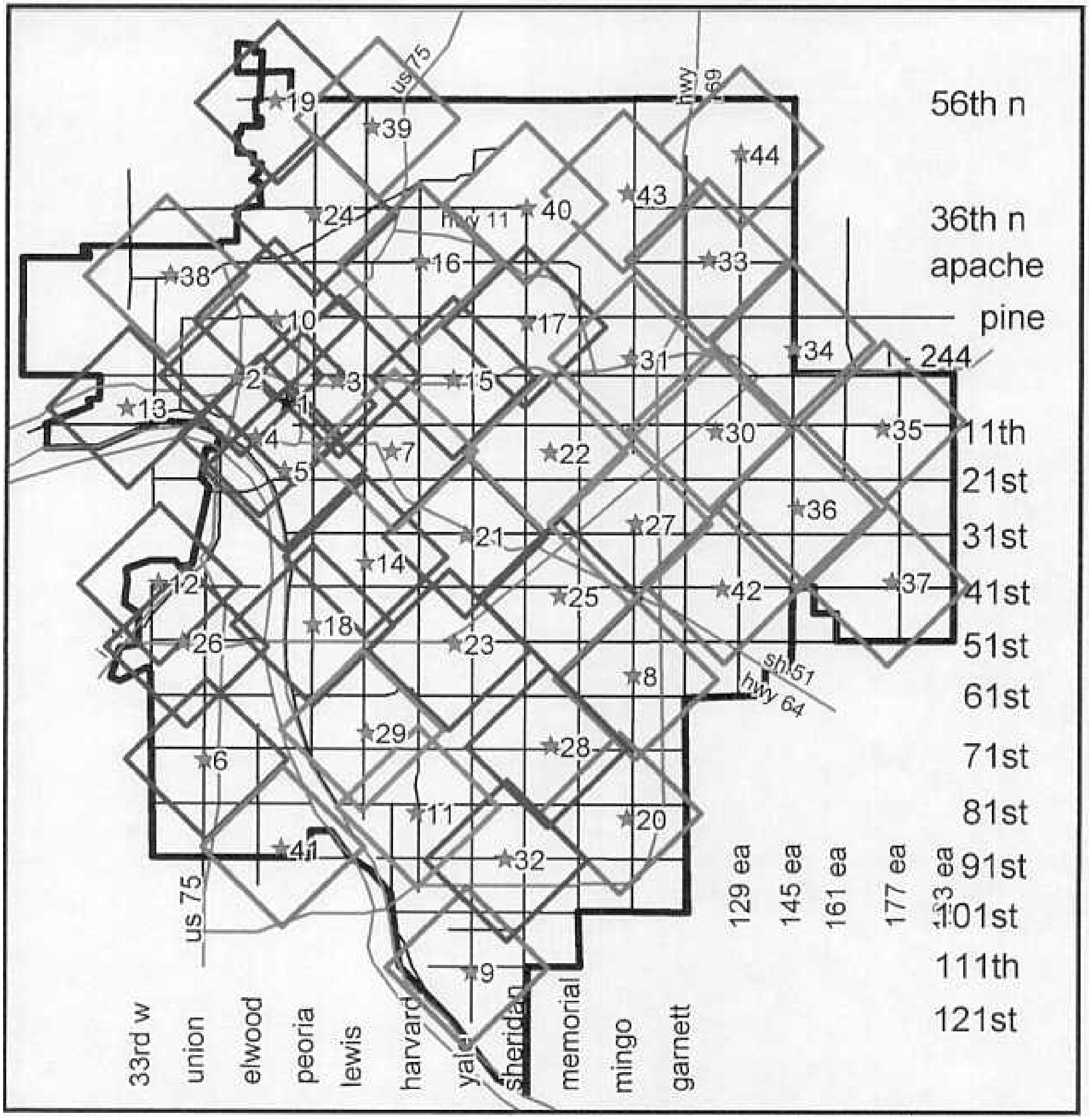



**Figure D1 - Long-Range Station Location Plan**